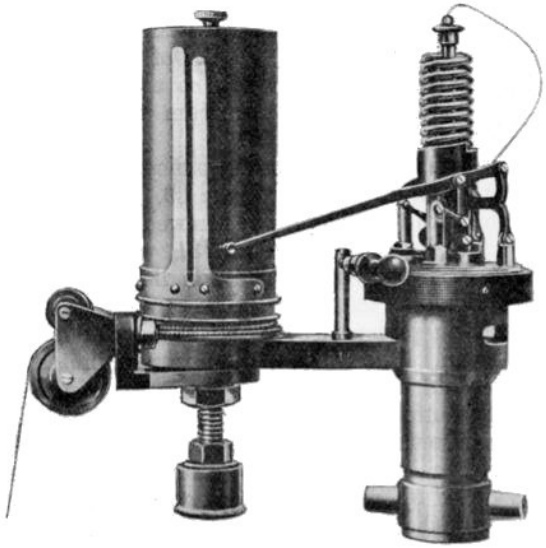
ECS Auto Tuning Manual



Background

1.1. Pressure Definitions

Auto Tuning is a built-in functionality of the ME/ME-B control system that adjusts the *indicated pressure* (p_i), the *compression pressure* (p_{comp}, depending on the engine type) and the *maximum pressure* (p_{max}). This is done partly to optimize the balance of the engine, partly to adjust the mean values, ensuring that the *max pressure* (p_{max}) and the compression pressure (p_{comp}) are kept within the design limits.
Figure 1 explains some of the pressure definitions during one combustion cycle.

NOTICE

Auto Tuning adjustment of P_{comp} is only possible on ME-engines and ME-B-engines applied with ME-V.

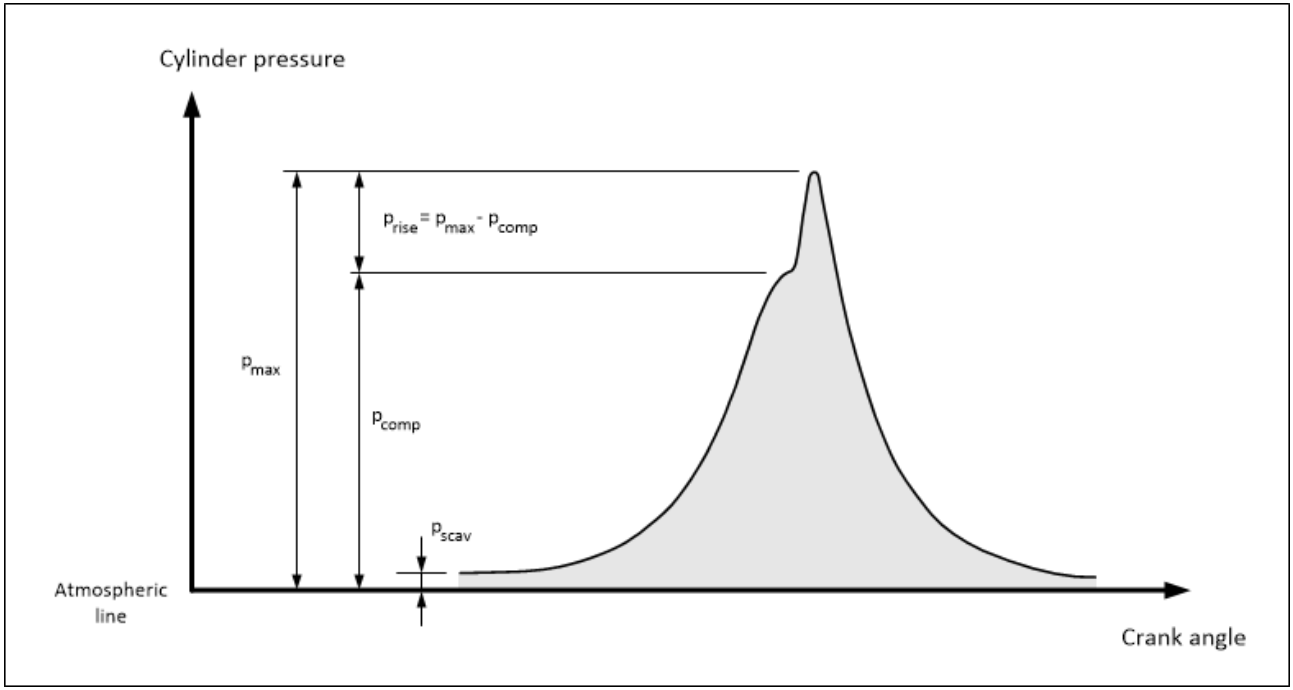


Figure 1 - Cylinder Pressure Diagram

1.2 Auto Tuning

The Auto Tuning consists of three parts:

1. Cylinder Pressure Balancing
2. Cylinder Pressure Mean Value Adjustment
3. Continues Adjustment of Cylinder Pressure Mean Values

It is import to distinguish between what the three parts does. Item 1 and 2 are one time operations, while item 3 runs continuously when started until cancelled by the operator or forced to stop by the control system. This is more thoroughly explained in Section 1.3, 1.4, and 1.5.

1.3 Auto Tuning Preconditions

For any part of The Auto Tuning (Balancing, Mean Value Adjustment, or Continues Mean Value Adjustment) a number of preconditions must to be fulfilled for it to function:

- Index is stable
  Engine has reached desired speed setpoint and engine load is stable
- Sufficient index
  Index is above a minimum level. Normal limit is 40% Index.
- Sensor values
  - Cylinder pressure sensors provide valid signals (Will display  if not ok)
  - Pressure deviations from reference is within allowed limits (Will display  if not ok)

The Preconditions are shown in the buttom of the Auto Tuning Screen (see Figure 2). If the condition is met it is marked with a green "✔" .

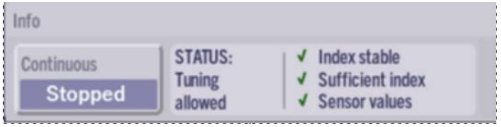


Figure 2 - Precondition for Auto Tuning

1.4 Cylinder Pressure Balancing

The Cylinder Pressure Balancing will balance pressures in *each* cylinder to minimize deviations from the mean value (see Figure 3).

The Balancing of Cylinder Pressures can be performed for p_i, p_{comp}, and p_{max}.
For the balancing to be successful all cylinder pressures must be in-between a predefined limit from the mean value. The measured difference between cylinder pressures must be within 3 bars for p_{comp} and p_{max}, and 0.5 bar for p_i.
Please note that Balancing of Cylinder Pressures is not part of the **Continuous** Auto Tuning.

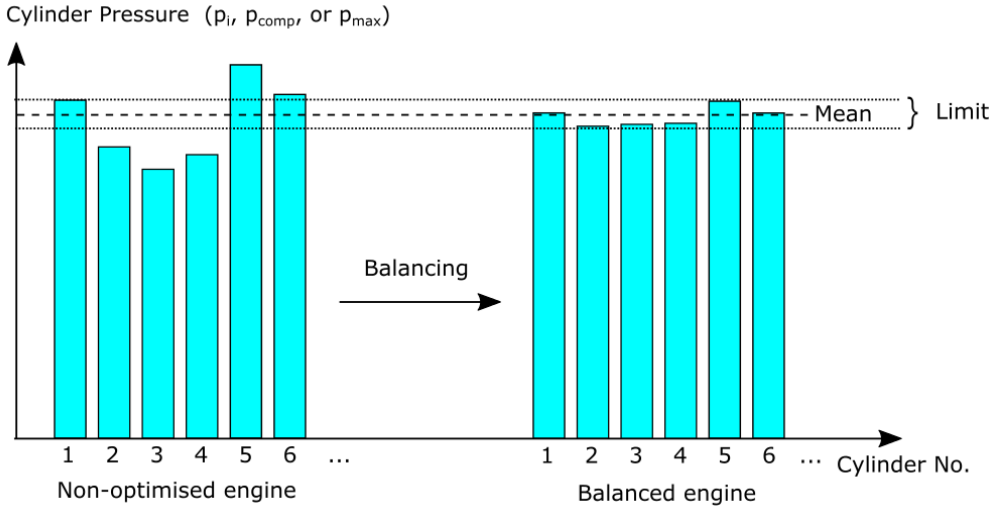


Figure 3 - Balancing Cylinder Pressures

1.5 Cylinder Pressure Mean Value Adjustment

The mean cylinder pressure can be adjusted in both positive and negative direction (see Figure 4). The mean adjustment will effectively add the same value to all cylinders.
Please note that Cylinder Pressure Balancing is unchanged when the mean value is changed.

The Mean Value Adjustment can **only** be performed for p_{comp}, and p_{max}.

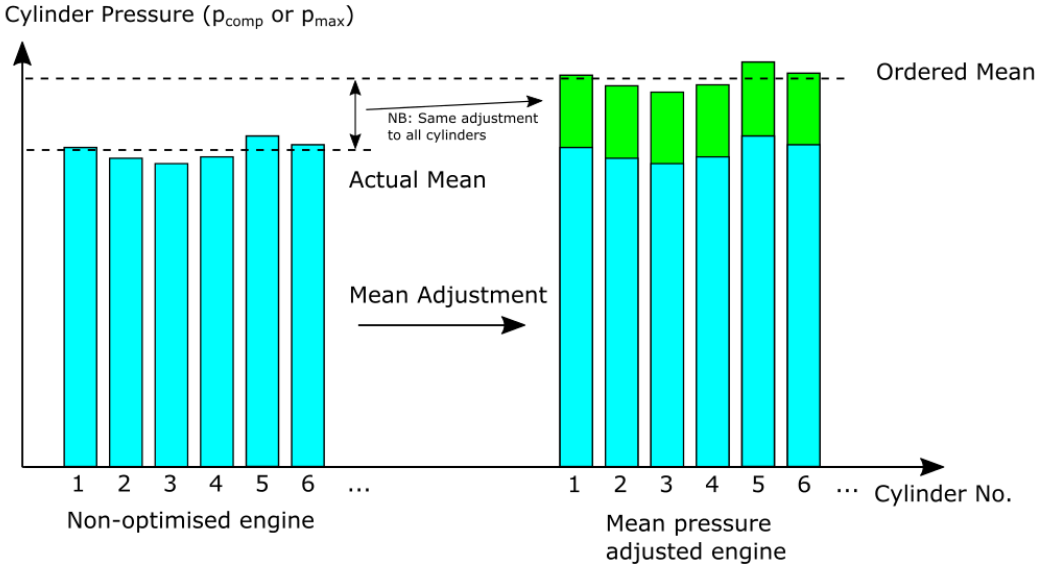


Figure 4 - Adjusting Mean Cylinder Pressures

2. Using Auto Tuning

2.1 Main Operating Panel (MOP)

The associated MOP screen is located at:

Engine ► *Operation* ► *Process Adjustment* ► *Auto Tuning*

In order to be able to press the buttons and activate Auto Tuning, *Chief*-level must be entered and the preconditions (See Section 1.3) must be met.

2.2 Step-by-Step Guide

The pressures can be adjusted by the Auto Tuning-functionality independently, but MAN Diesel & Turbo recommends adjustments in the following order:

1.	Verification and Adjustment of the Estimated Load	(Figure 8)
2.	Balancing of P_i	(Figure 10 to Figure 13)
3.	Balancing of P_{comp}	(Figure 14)
4.	Balancing of P_{max}	(Figure 15)
5.	Mean adjustment of P_{comp} (if possible for given SW Release / Engine)	(Figure 16)
6.	Mean adjustment of P_{max}	(Figure 17)
7.	Start Continuous Auto Tuning	(Figure 18 and Figure 19)

Figure 8 - Figure 19 demonstrates the complete procedure in details.

2.2.1 Verification and Adjustment of the Estimated Load

During Shop test the correct relation between P_{Max}, P_{comp}/P_{scav}, and the engine load is commissioned. Here a water brake is used as the reference point for the engine load.

During operation the estimated engine load is used to determine the pressure setpoints for P_{Max} and P_{comp}/P_{scav} and therefore an incorrect engine load estimation will result in the wrong setpoints for the Auto Tuning.

In Figure 5 an example of P_{Max} setpoint related to load is shown. It is seen that a too high estimation of the engine load will result in a too high P_{Max} setpoint and vice versa.

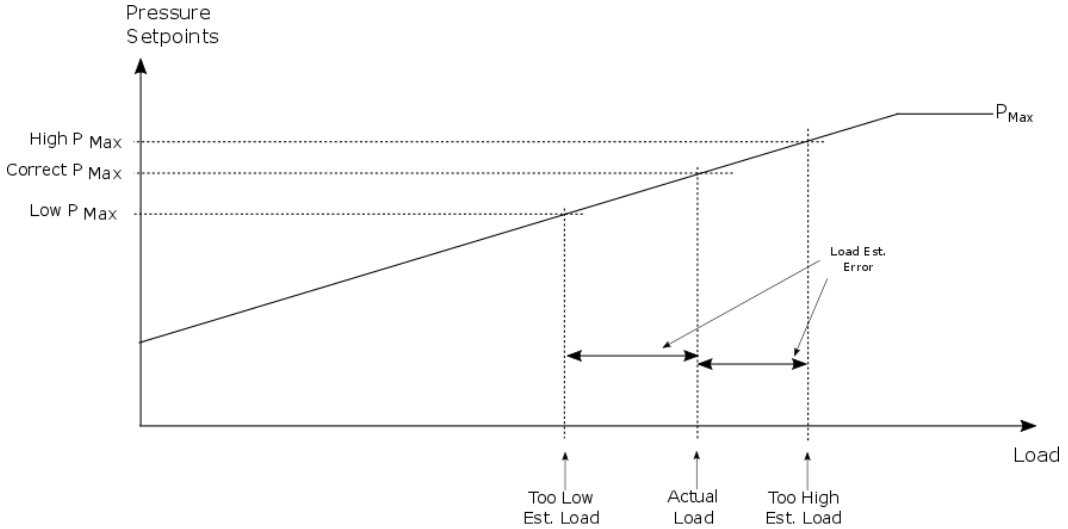
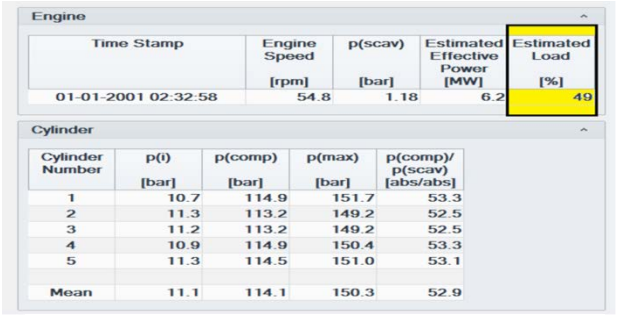


Figure 5 - P_{Max} Setpoint and Estimated Engine Load

For this reason the first thing that should be checked before starting the Auto Tuning is that the load estimation is correct.

The “Estimated Engine Load” is displayed on the Engine Process Information Screen (See Figure 7). This value should match the “Estimated Load” from the PMI (see Figure 6). Alternatively the torque-meter value can be used as reference.

Figure 7 - Estimated Engine Load ECS



Engine

Time Stamp	Engine Speed [rpm]	p(scav) [bar]	Estimated Effective Power [MW]	Estimated Load [%]
01-01-2001 02:32:58	54.8	1.18	6.2	49

Cylinder

Cylinder Number	p(i) [bar]	p(comp) [bar]	p(max) [bar]	p(comp)/ p(scav) [abs/abs]
1	10.7	114.9	151.7	53.3
2	11.3	113.2	149.2	52.5
3	11.2	113.2	149.2	52.5
4	10.9	114.9	150.4	53.3
5	11.3	114.5	151.0	53.1
Mean	11.1	114.1	150.3	52.9

Figure 6 - Estimated Load PMI

An acceptable deviation between ECS and PMI/Torque-meter is:

- 2 – 3 % when PMI equipment has been calibrated on Shop test
- 4 – 6 % when PMI equipment has **not** been calibrated on Shop test

The “Estimated Engine Load ECS” is corrected by changing the Fuel Quality on the MOP “Fuel Quality”-Screen.

The first thing the operator should do is to enter values into the Fuel Specific Data (see Figure 8).
From this data the “Suggested Fuel Quality Offset” is calculated. The “Suggeseted Fuel Quality Offset” displays a recommended value for the Operator to enter into the “Applied Fuel Quality Offset” .

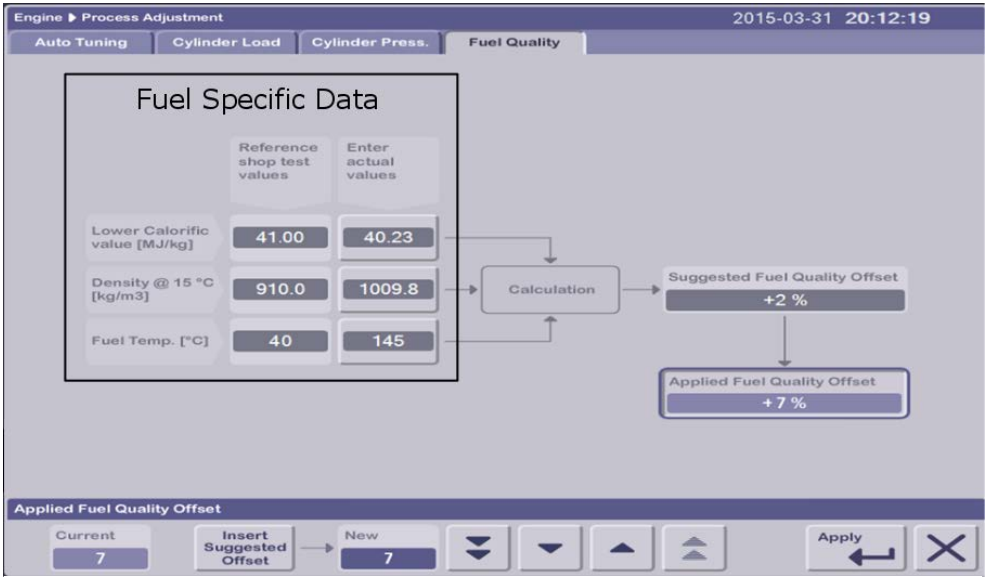


Figure 8 - Fuel Quality Adjustemt Screen

After the operator has entered the Suggested Value into the “Applied Fuel Quality Offset” he/she should check the “ECS estimated engine load”.

If the “ECS estimated engine load” does not match the “PMI engine load” after using the suggested value the “Applied Fuel Quality Offset” will need to be corrected additionally.

The following relation holds when the operator changes the fuel quality.

- Increaing the “Applied Fuel Quality Offset” will decrease the estimated engine load on ECS
- Decreasing the “Applied Fuel Quality Offset” will increase the estimated engine load on ECS

The needed Fuel Quality Adjustment may be different at different engine speed why the Fuel Quality Offset may need to be corrected when the engine speed changes noticeably.

2.2.2 Balancing Of P_i

The balancing of P_i is done by the following:

1. Press the large P_i deviation button
2. Press the P_i Button (in the buttom of the screen)
3. “STATUS:” (in the buttom of the screen) “Tuning in Progress”
4. “STATUS:” “Tuning Allowed” and “REPORT: Last Tuning succesful”

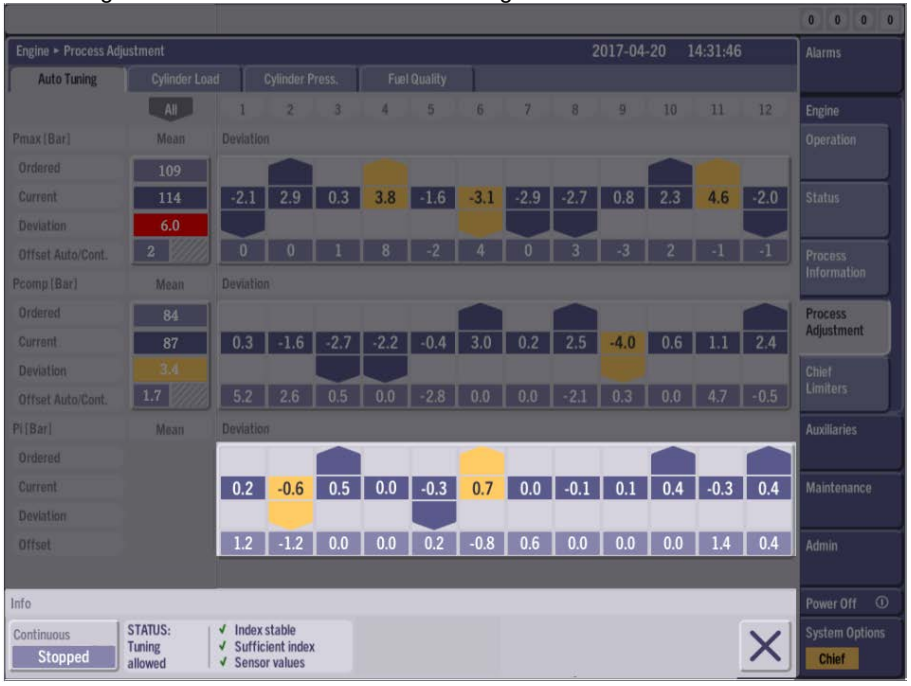


Figure 9 - Before Balancing P_i

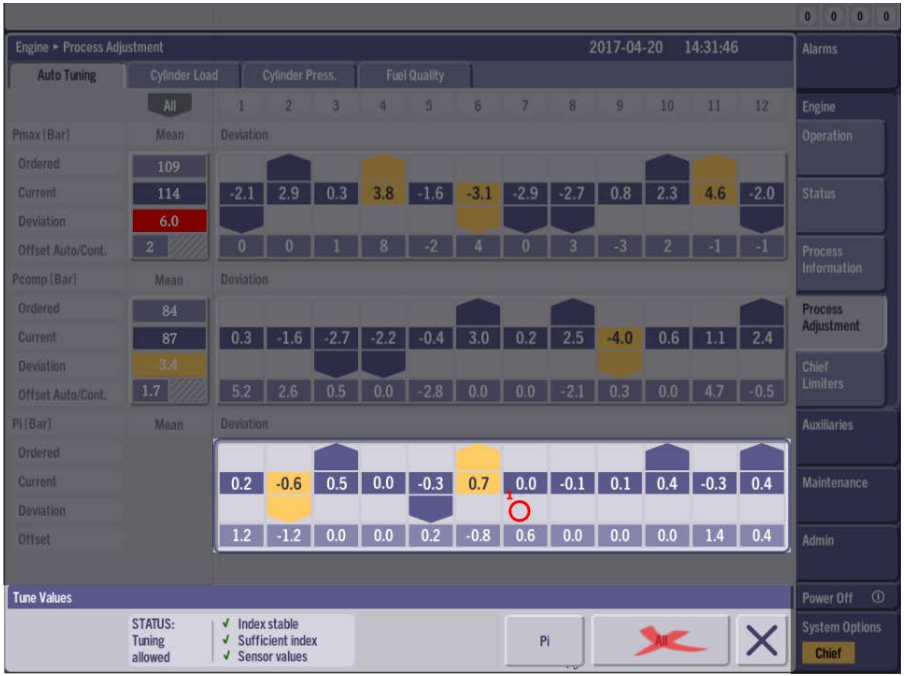


Figure 10 - Balancing P_i _ Step 1: Press P_i deviation button, Tool bar appear

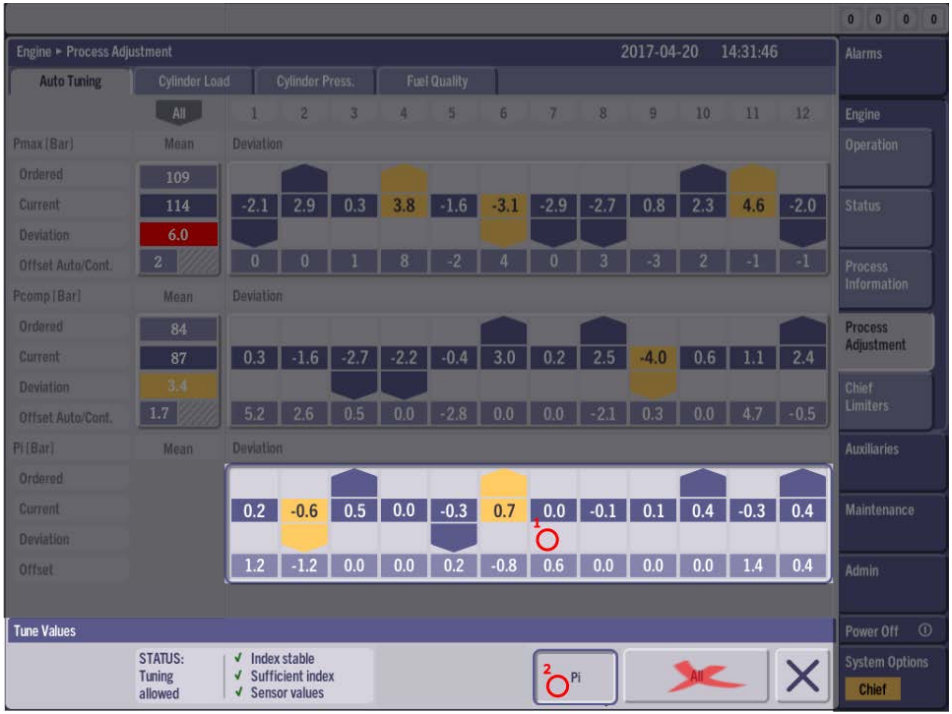


Figure 11 - Balancing P_i - Step 2: Press P_i button, starting P_i adjust

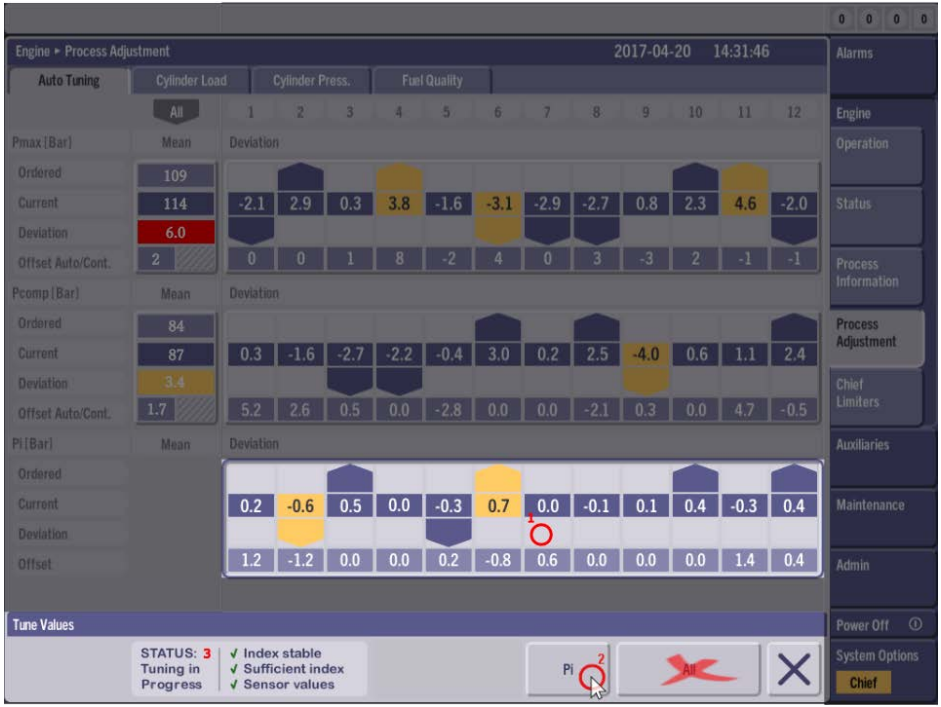


Figure 12 - Balancing Pi - Step 3: Tuning in Progress

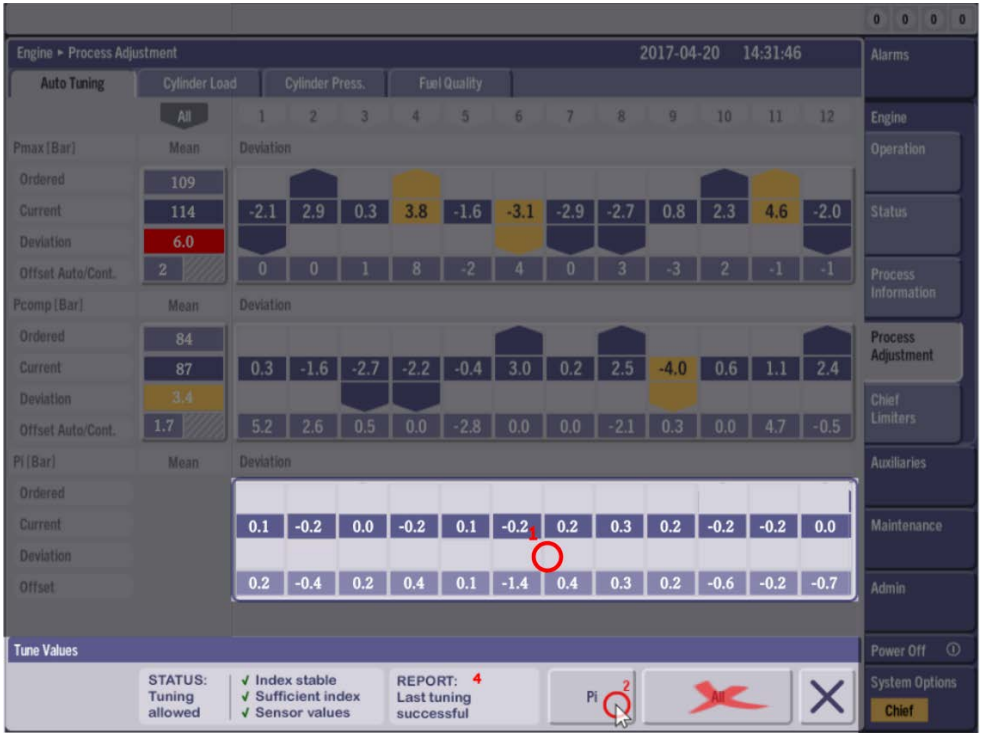


Figure 13 - Balancing Pi - Step 4: Tuning sucessful, Deviations corrected

2.2.3 Balancing Of P_{Comp}

The balancing of P_{Comp} is done by the following:

1. Press the large P_{Comp} deviation button
2. Press the P_{Comp} Button (in the buttom of the screen)
3. “STATUS:” (in the buttom of the screen) “Tuning in Progress”
4. “STATUS:” “Tuning Allowed” and “REPORT: Last Tuning succesful”

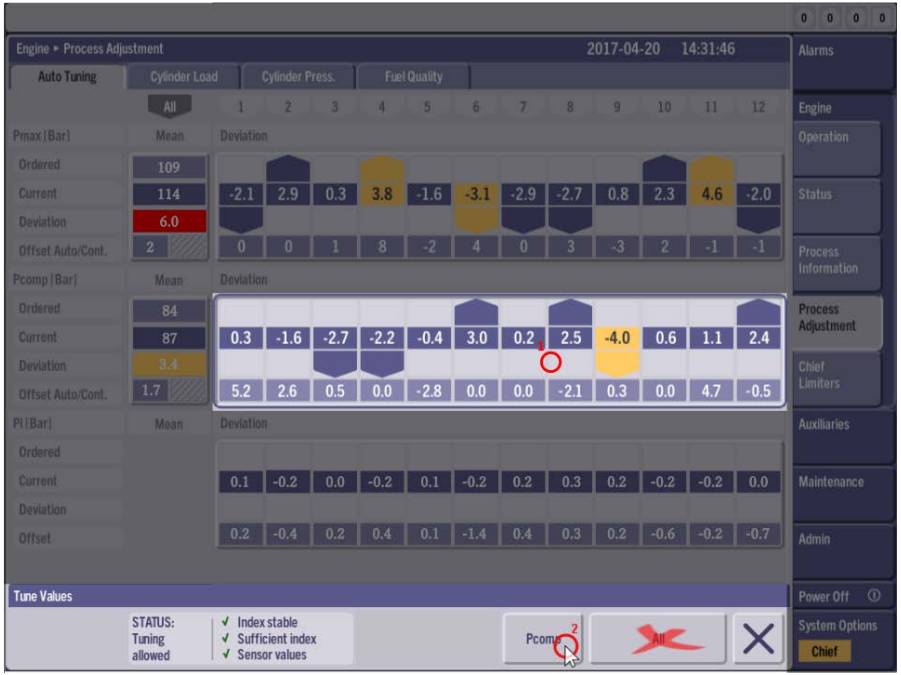


Figure 14 - Balancing of P_{comp}

2.2.4 Balancing of P_{Max}

The balancing of P_{Max} is done by the following:

1. Press the large P_{Max} deviation button
2. ress the P_{Max} Button (in the buttom of the screen
3. “STATUS:” (in the buttom of the screen) “Tuning in Progress”
4. “STATUS:” “Tuning Allowed” and “REPORT: Last Tuning succesful”

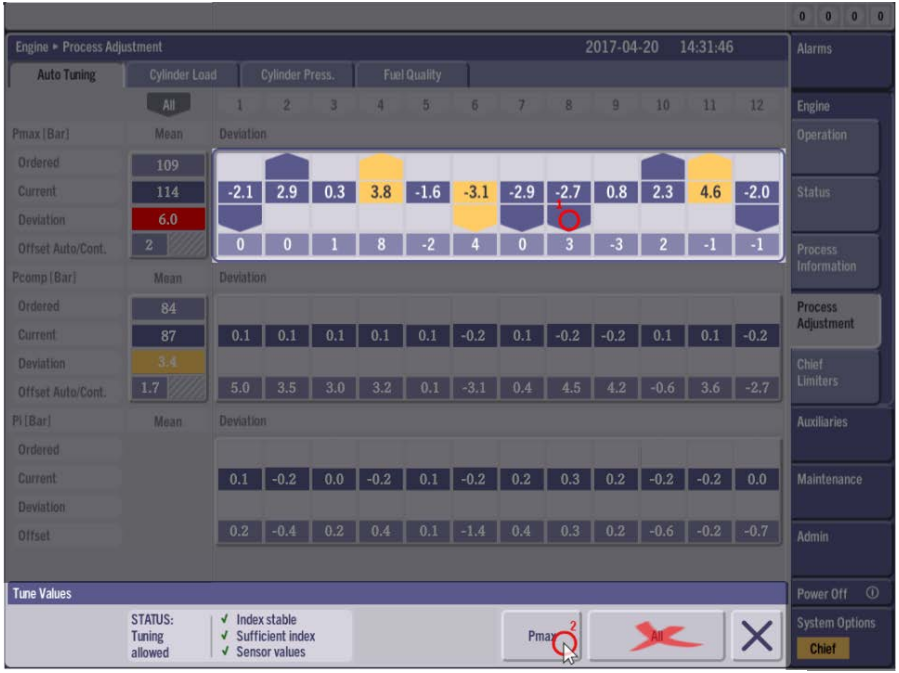


Figure 15 - Balancing of P_{Max}

2.2.5 Mean Adjustment P_{Comp}

The adjustment of Mean P_{Comp} is done by the following:

1. Press the large P_{Comp} mean button
2. Press the P_{Comp} Button (in the buttom of the screen)
3. “STATUS:” (in the buttom of the screen) “Tuning in Progress”
4. “STATUS:” “Tuning Allowed” and “REPORT: Last Tuning succesful”

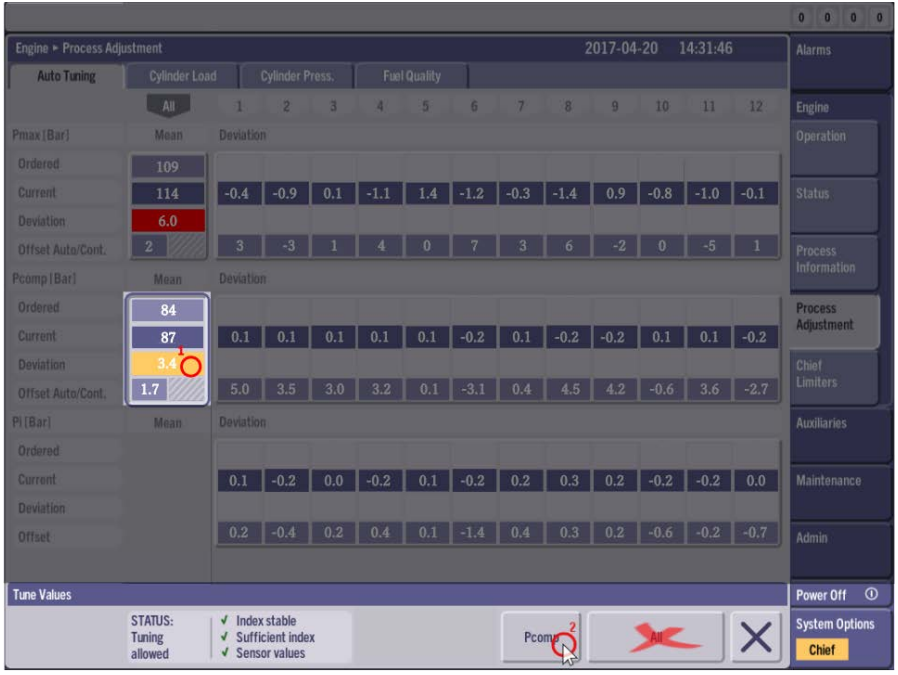


Figure 16 - Mean Adjustment P_{Comp}

2.2.6 Mean Adjustment P_{Max}

The adjustment of Mean P_{Max} is done by the following:

1. Press the large P_{Max} mean button
2. Press the P_{Max} Button (in the buttom of the screen)
3. “STATUS:” (in the buttom of the screen) “Tuning in Progress”
4. “STATUS:” “Tuning Allowed” and “REPORT: Last Tuning succesful”

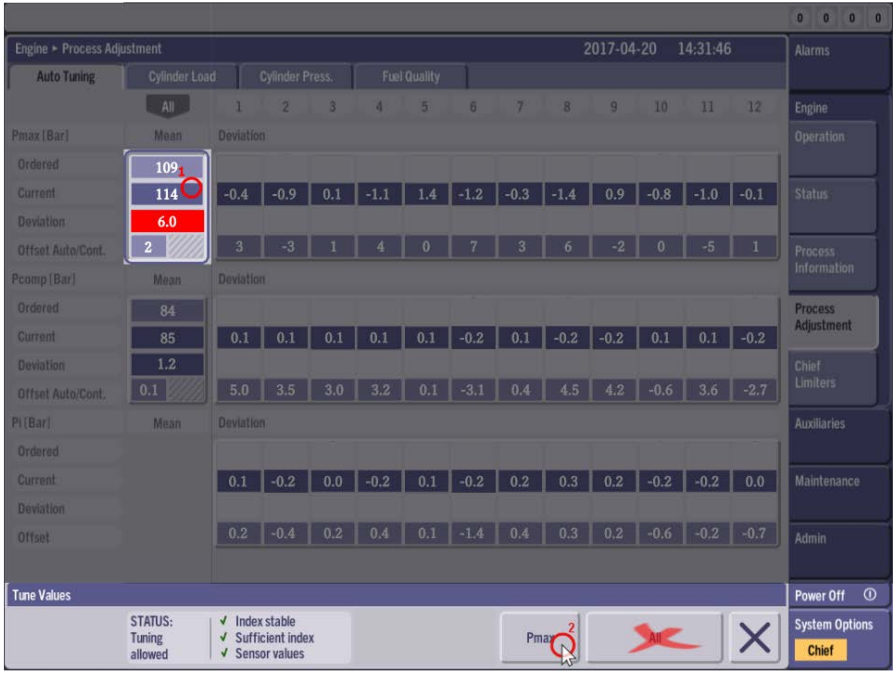


Figure 17 - Mean Adjustment PMax

2.2.7 Start Continuous Auto Tuning

After doing the pressure balancing and mean adjustment the engine has been auto tuned. It is important to note that these steps are all one time operations and must be redone again later if running conditions change and if balance is not ok. If the operator want the control system to automatically and continuously correct the **mean** pressure for P_{Max} and P_{Comp} (not possible for all engines) he/she can choose to enable the Continuous Auto Tuning.
As already mentioned the Continuos AutoTuning only makes corrections to the mean value and thus has no effect on the cylinder balancing.

Starting the Continuos Auto Tuning is done by the following (newer SW Releases):

1. Press the Continuous button
2. Press Start

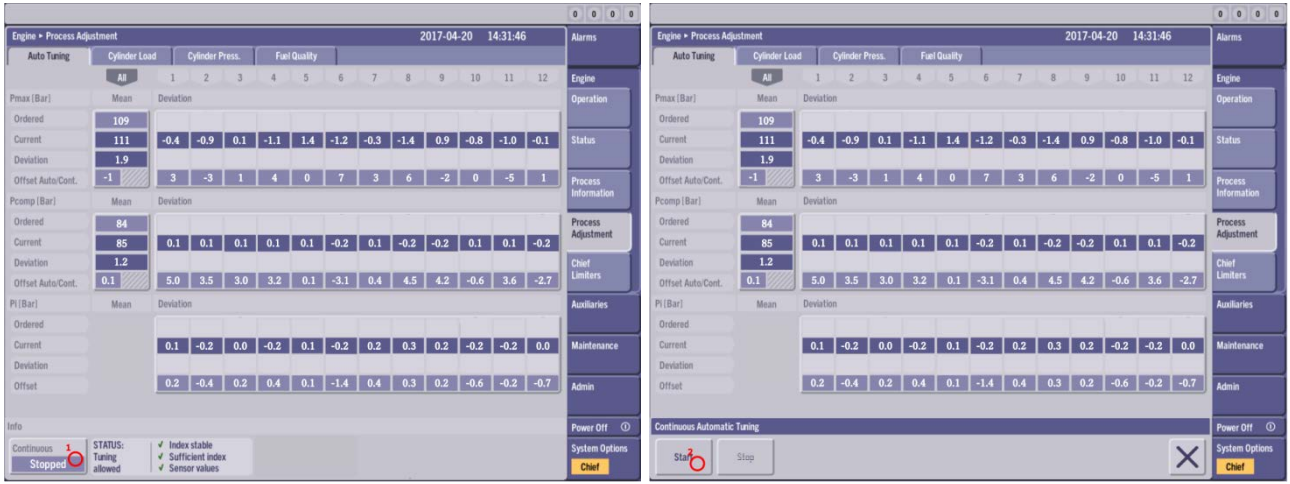


Figure 18 - Continuous Auto Tuning

For older Software Releases the Continuous Auto Tuning can be enabled for P_{Max} and P_{Comp} seperately. MDT recommends that if continuous is available for both P_{Max} and P_{Comp}, continuous Auto Tuning should always be started for both.

In Figure 19 starting Continuous Auto Tuning for P_{Max} is shown. The procedure is similar for continuous P_{comp} Auto Tuning.

Starting the Continuos Auto Tuning is done by the following (older SW Releases):

1. Press the P_{Comp} Mean button (Not avaiable on all SW releases / Engines)
2. Press the On button (Not avaiable on all SW releases / Engines)
3. Press the P_{Max} Mean button
4. Press the On button

NOTICE

If continuous Auto Tuning is only available for P_{Max} it is important to observe the P_{rise} for each cylinder.

NOTICE

The 'All'-button should never be used; as it will tune the pressures in random order and therefore not get the optimal result.

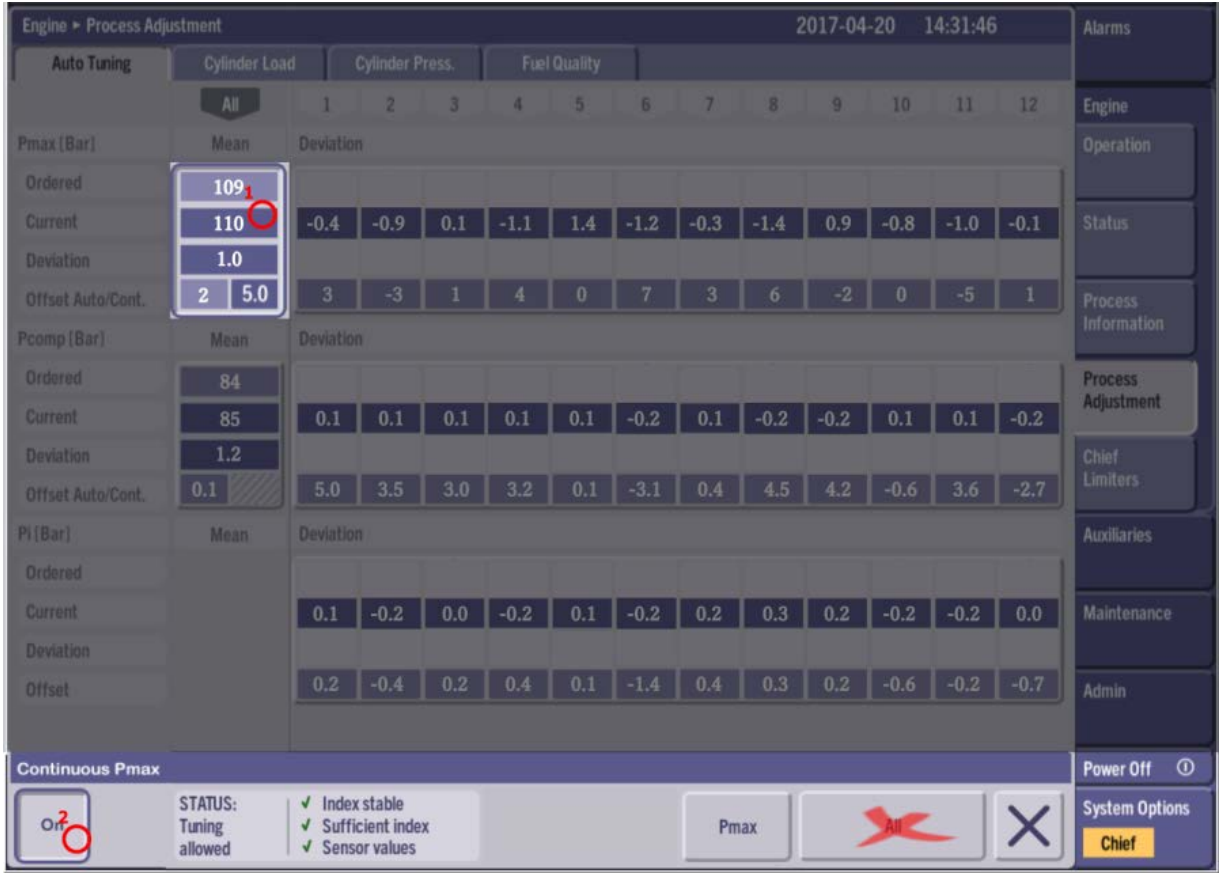


Figure 19 - Continuous Auto Tuning – Older SW Releases

It should be noted that Continuous Auto Tuning is enabled when the “On” button is pressed and that it is disabled when the “On” button is **not** pressed. See Figure

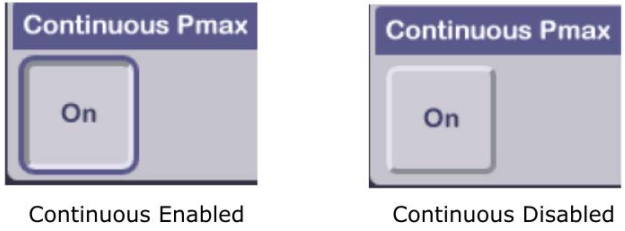


Figure 20 - Continuous Auto Tuning Enabled or Disabled

When Continuous Autotuning is running the continuous adjustment is shown in the button right corner of the Mean Label.
NB: If the continuous value is high, MDT recommend to redo step 2.2.5 and 2.2.6 again.

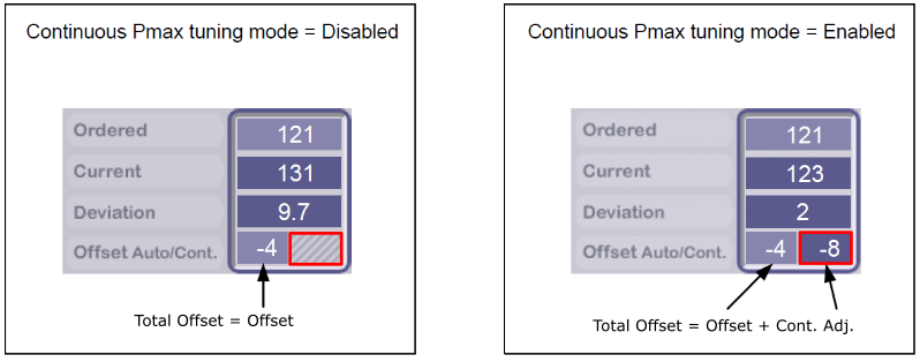


Figure 21 – Offset Value and Continuous Adjustment. Example P_{Max}

A. Auto Tuning Screen Overview

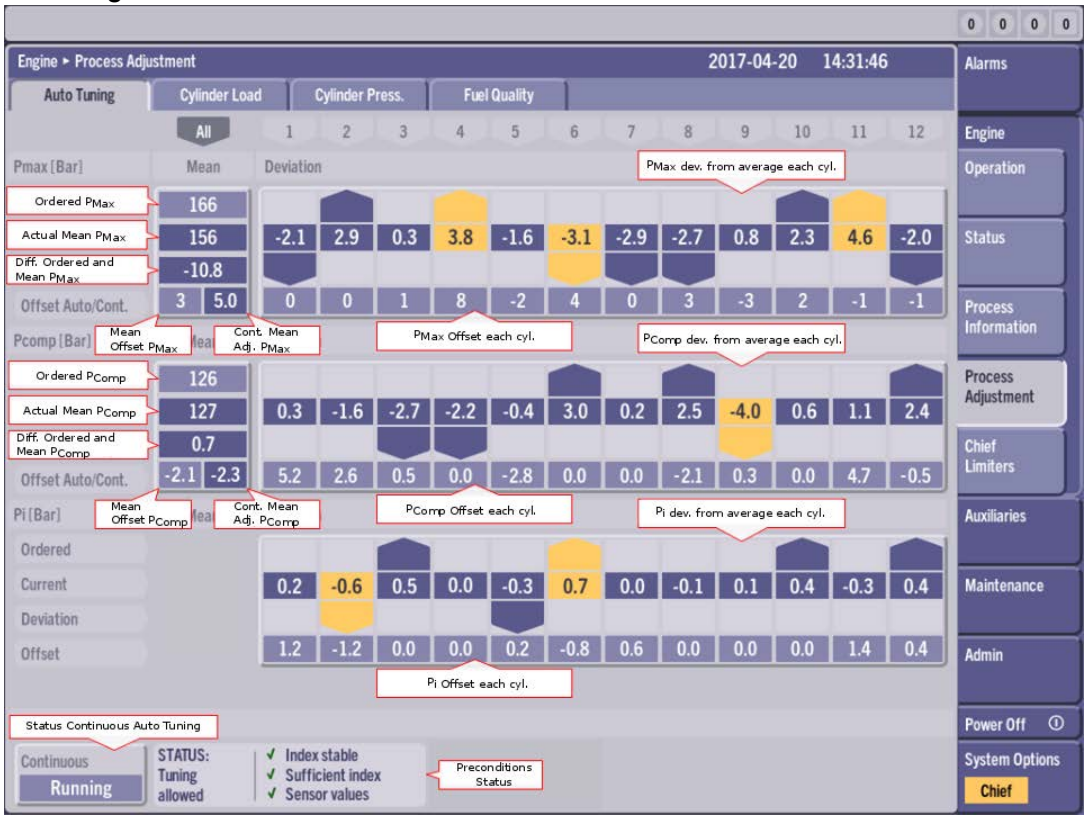


Figure 22 - The Auto Tuning MOP-screen explained

B. Running Mode Screen

On the Running Mode Screen the Maximum pressure (Yellow) and P_{comp}/P_{scav} (Blue) are shown. These values are taken from lookup tables and are dependent on the Estimated Engine Load.

The Measured P_{scav} (Green) is shown by its actual pressure value on the Running Mode Screen.
To get the absolute P_{scav} value 1 bar is added to the actual P_{scav}.

The Ordered Compression Pressure (Red) is given by multiplying the absolute P_{scav} and the P_{comp}/P_{scav} values.

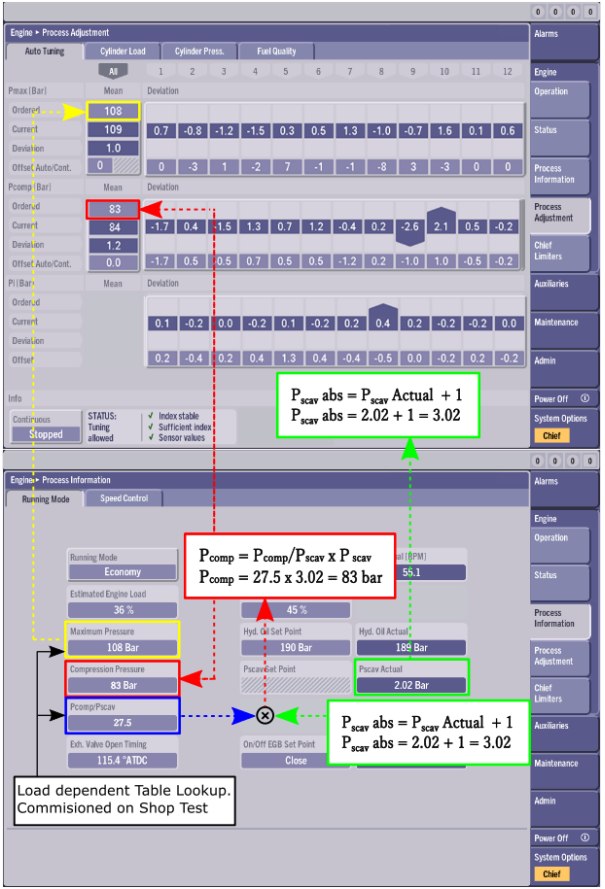


Figure 23 - Running Mode Screen

C. Cylinder Pressure Screen

On the Cylinder Pressure Screen P_{max} and P_{comp}/P_{scav} can be corrected manually. The operator has the option to correct both the mean value and for each cylinder.

P_{comp}/P_{scav} is shown in blue, while P_{comp} is shown in red. It is important to note that the operator only have the option to correct the P_{comp}/P_{scav}, which indirectly will change the P_{comp} correction.

The P_{max} offset can be set directly by the operator.

These Values are the same values that are adjusted by the Auto Tuning in Section 2.2.3 – 2.2.6.

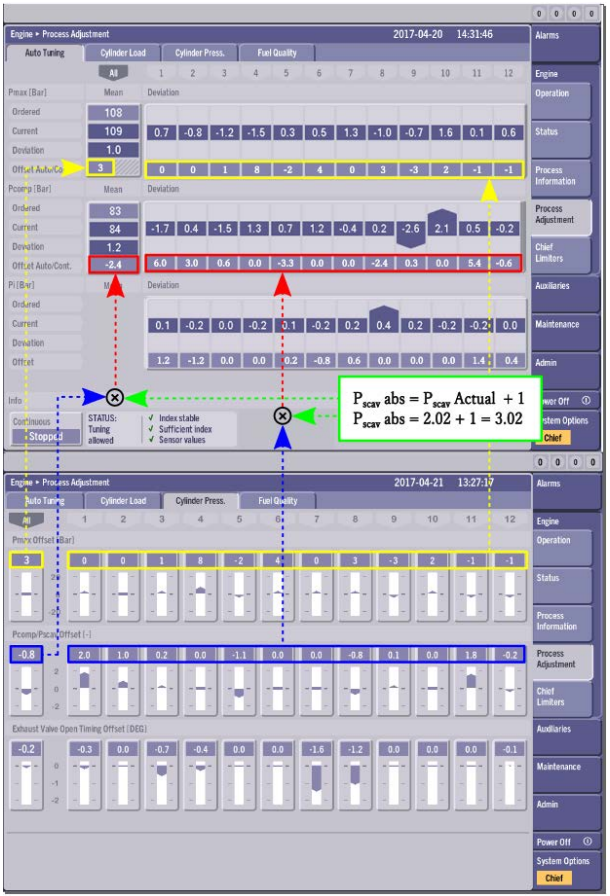


Figure 24 - Cylinder Pressure Screen

D. Cylinder Load Screen

On the Cylinder Load Screen the P_i deviation can be corrected. The Operator has the option to correct the P_i value for each cylinder.

The Offset values will change the Load for the individual cylinder and thus change the P_i value for that cylinder.

The “High Load Offset” will change the P_i for the individual cylinder at 100 % load, while the “Low Load Offset” will change it at 0 % load.

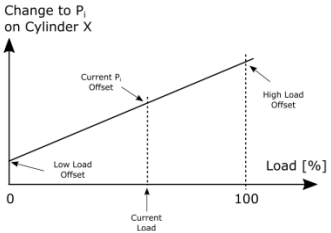


Figure 26 - Pi Adjustemts on Cylinder x

It is important to note that the Mean Value for P_i is a result of the actual engine power, why it is constant for a given work done by the engine. For this reason only the balance of P_i (The relative work done by each individual cylinder) can be adjusted and not the mean P_i value.

NB: When using the P_i Balance Auto Tuning only the High Load Offset is corrected.

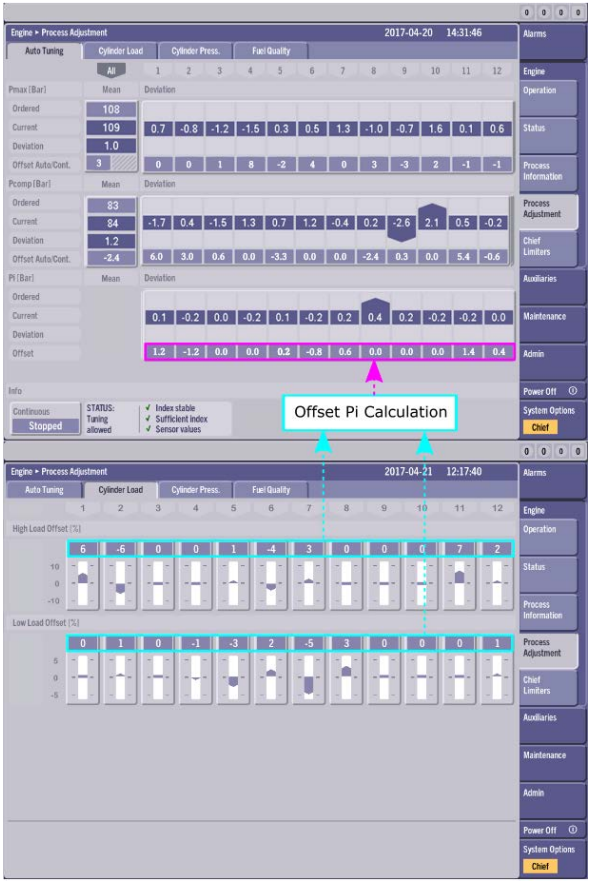


Figure 25 - Cylinder Load Screen

E. Frequently Asked Questions

Some arrows in the Auto Tuning screen are red. What does that mean and what should I do?

Predefined threshold icons indicate how large the deviation is for the measured pressures.
For large deviations a red icon is shown. This may indicate a mechanical failure and should be investigated.

For the mean value:

Threshold color	P_{max} (bar)	P_{comp} (bar)
	-3 to 3	-3 to 3
	3 to 5 or -3 to -5	3 to 5 or -3 to -5
	>5 or <-5	>5 or <-5

For the deviation panel:

Threshold icon	P_{max} (bar)	P_{comp} (bar)	P_i (bar)
	>20	>20	>2
	3 to 20	3 to 20	0.5 to 2
	1 to 3	1 to 3	0.2 to 0.5
	-1 to 1	-1 to 1	-0.2 to 0.2
	-1 to -3	-1 to -3	-0.2 to -0.5
	-3 to -20	-3 to -20	-0.5 to -2
	< -20	< -20	<-2

For smaller deviations use the mean chief correction to offset the values and/or enable continuous auto tuning (see Figure 22).

What about the “Cylinder Load”-screen and the “Cylinder Press.”-screen? Should I use them?

The “Cylinder Load” and “Cylinder Press.”- screen can be used for minor adjustment of Cylinder Pressures and Engine Load on individual cylinders. For larger deviations the operator should do the full Auto Tuning Procedure described in Section 2.2.1 – 2.2.6.

Why can’t I adjust the mean value of P_i?

The mean P_i is not adjustable, but an indirect measure of the actual engine load. The Operator can only adjust how much of this load each cylinder should do by the auto tuning P_i deviation or the “Cylinder Load”-Screen adjustments.

It is important to ensure that the Estimated Load match the Actual Load (indirectly given by the mean P_i). How to do this is described in Section 2.2.1.

The calculations don’t match? Why?

Some delays may occur in the update of the MOP screen and/or some values may be rounded off.